

Embolization of Arteriovenous Malformation

Efficacy and Safety of Preoperative Embolization Followed by Surgical Resection of AVM

H. NAGASHIMA, K. HONGO*, S. KOBAYASHI*, T. TAKAMAE*, H. OKUDERA**, J.I. KOYAMA*, F. OYA*, Y. MATSUMOTO***

Interventional Neuroradiology Center, Aizawa Hospital, Matsumoto; Japan

* Department of Neurosurgery, Shinshu University School of Medicine, Matsumoto; Japan

** Department of Emergency and Disaster Medicine, Toyama Medical and Pharmaceutical University, Toyama; Japan

*** Department of Neuroendovascular Therapy, Kohnan Hospital, Sendai; Japan

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Summary

Treatment options for cerebral arteriovenous malformation (AVM) are still controversial due to the recent result of stereotactic radiosurgery and the improved result of microsurgical resection. We investigated previously treated AVM cases and discussed the efficacy and safety of preoperative embolization especially for microsurgical resection of high-grade AVM in the Spetzler-Martin grading.

Efficacy of preoperative embolization was evaluated based on 126 previously treated AVM cases at Shinshu University Hospital during the last 25 years. The safety of embolization was evaluated based on our previously-embolized 58 AVM cases (91 procedures) in the last 11 years after introduction of preoperative embolization for AVM. In all 126 cases, 82 were treated before introduction of embolization and 44 were treated after introduction of embolization. In 82 cases of the pre-embolization era, 63 lesions were removed totally in 63 AVMs (77%), partially resected in 11 (13%) and untreated in eight (10%). In 74 surgically removed cases, 11 (15%) cases showed severe intra/postoperative bleeding. In 44 cases of the embolization era, lesions were removed totally in 29 AVMs (66%), disappeared only with embolization in one (2%), disappeared with radiosurgery in seven (16%) and

were untreated in five (11%). In 32 surgically removed cases, only one (2%) case showed severe intra/postoperative bleeding.

In all 58 embolized cases, 44 were surgically removed, six were treated with radiosurgery, one was eliminated with embolization alone and six were partially obliterated and followed up for their location. In 91 procedures for 58 cases, two haemorrhagic and three ischemic complications occurred, three were transient and two remained having neurological deficits.

The introduction of preoperative embolization improved the total removal rate and reduced the intra/postoperative bleeding rate in surgical removal of AVM. The total risk of embolization is low and well-designed preoperative embolization makes surgical resection safer even in high-grade AVM in the Spetzler-Martin grading.

Introduction

Until late 1980's, surgical resection of the cerebral arteriovenous malformation (AVM) was one of the most important subjects in the neurosurgical field. Since the introduction of stereotactic radiosurgery in early 1990's, main stream of AVM treatment was changed to stereotactic radiosurgery due to its low peri-surgical complication rate¹⁻⁴. However, long-term follow-up after stereotactic radiosurgery on AVM resulted in

relatively low complete obliteration rate and high treatment-related complication rate⁵⁻⁹.

According to the long-term results of stereotactic radiosurgery and owing to the modern technical improvement of microneurosurgery, treatment options for AVM again became controversial. The American Heart Association recommended that surgical extirpation should be considered for the low-graded AVM in the Spetzler-Martin grading and only the lesions in which surgery offers increased risk based on its anatomical feature, stereotactic radiosurgery was recommended¹⁰. It is also recommended that a combined modality approach with embolization followed by surgery for selected cases of high-graded AVM.

Authors investigated previously treated AVM cases and discussed the efficacy of preoperative embolization for surgical resection in high-graded AVM and safety of preoperative embolization.

Material and Methods

Total 126 AVM cases were treated in Shinshu University Hospital since April 1978 to March 2003. Embolization of AVM was introduced in 1992, and total 58 cases (91 procedures) were embolized in Shinshu University and its affiliated hospitals.

After introduction of embolization, all AVM cases were evaluated by both interventional neuroradiologist (HN) and neurosurgeons (KH, SK) before starting treatment. Surgical total resection of AVM was considered as a principle, and preoperative embolizations were considered depending on the size, location and structure of an AVM. Stereotactic radiosurgery with or without embolization was considered only in cases of unruptured small AVM located in the eloquent area.

The purpose of embolization of AVM is to simplify the haemodynamic structure by occluding the nidus in order to reduce the intranidal blood flow and to dissect the margin of nidus from adjacent eloquent area¹¹. All embolizations were performed under local anesthesia after functional test with barbiturate and lidocaine¹². Embolic material was selected according to the neurosurgeon's preference.

Efficacy of preoperative embolization was evaluated based on previously treated 126 AVM cases in Shinshu University Hospital. The 126 cases were divided into two groups: the

AVM cases treated before introduction of preoperative embolization and the cases after introduction of embolization. Surgical results, complications and number of open surgeries were investigated.

Safety of embolization for AVM was evaluated based on our previously-embolized 58 AVM cases since 1992. Results and embolization-related complications were investigated in total 91 procedures.

Results

The total 126 cases treated in Shinshu University Hospital, 79 were men and 47 were women, age ranged from three to 74 years old. One hundred-five AVM removed surgically, seven treated with stereotactic radiosurgery, 13 followed-up without treatment.

Eighty-two of 126 cases were treated before introduction of embolization (pre-embolization era) and 44 cases were treated after introduction of embolization (embolization era). Spetzler&Martin grades of pre-embolization era were I in five cases (6%), II in 32 (39%), III in 21 (26%), IV in 19 (23%), and V in five (6%). Spetzler&Martin grades of embolization era were I in two cases (2%), II in 11 (25%), III in 20 (45%), IV in six (14%), and V in six (14%). Of 82 cases of pre-embolization era, 74 (90%) were removed surgically and eight (10%) were not treated and followed-up. Of 44 cases of embolization era, 31 (70%) were removed surgically, one (2%) disappeared only with embolization, seven (16%) treated with stereotactic radiosurgery and five (11%) were not treated.

Of 74 surgically removed cases in pre-embolization era, 63 (85%) underwent total removal, 11 (15%) resulted in partial removal and 21 (28%) required multi-staged surgery. Of 31 surgically removed cases in embolization era, all cases underwent total removal and four (13%) required multi-staged surgery.

Surgery-related complications were seen in 11 (15%) cases and unexpected residual nidus was seen in nine (12%) cases in pre-embolization era. Surgery-related complications included four intraoperative uncontrollable bleeding, four postoperative severe bleeding and three postoperative late bleeding. Surgery-related complications were seen only in one (3%) case and unexpected residual nidus was seen in one (3%) case in the early period of

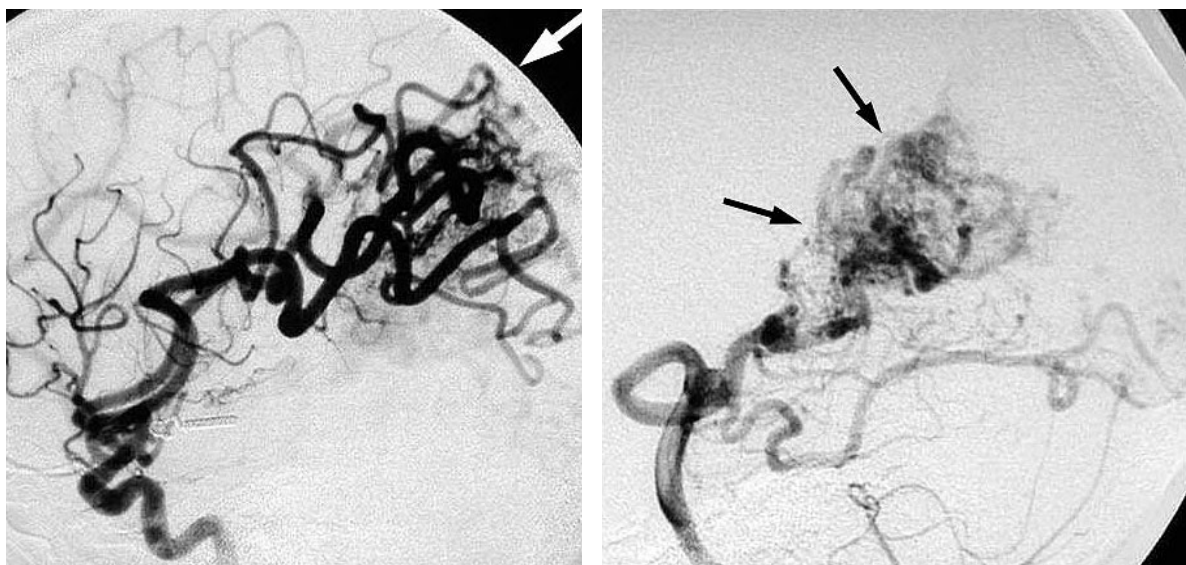


Figure 1 Pre-embolization left internal carotid (left) and vertebral (right) artery angiogram of a 24-year-old lady. Open and closed arrows indicate the margin between the nidus and normal brain.

embolization era. This surgery-related complication was intra- and postoperative severe bleeding following the incomplete preoperative embolization.

The total 58 embolized cases, 31 were men and 27 were women, age ranged from five to 76 years old. Forty-four AVM were removed, six treated with stereotactic radiosurgery, one disappeared with embolization alone and remain-

ing six were observed following partial embolization for the deeply-seated AVM.

In 91 procedures for 58 AVM cases, the initial 43 procedures (26 cases) were obliteration with poly-vinyl acetate, the latter 41 procedures (30 cases) were obliteration with N-butyl-2 cyanoacrylate (NBCA) and the remaining two cases were obliteration utilizing other materials (coil, silk)^{11,13}.

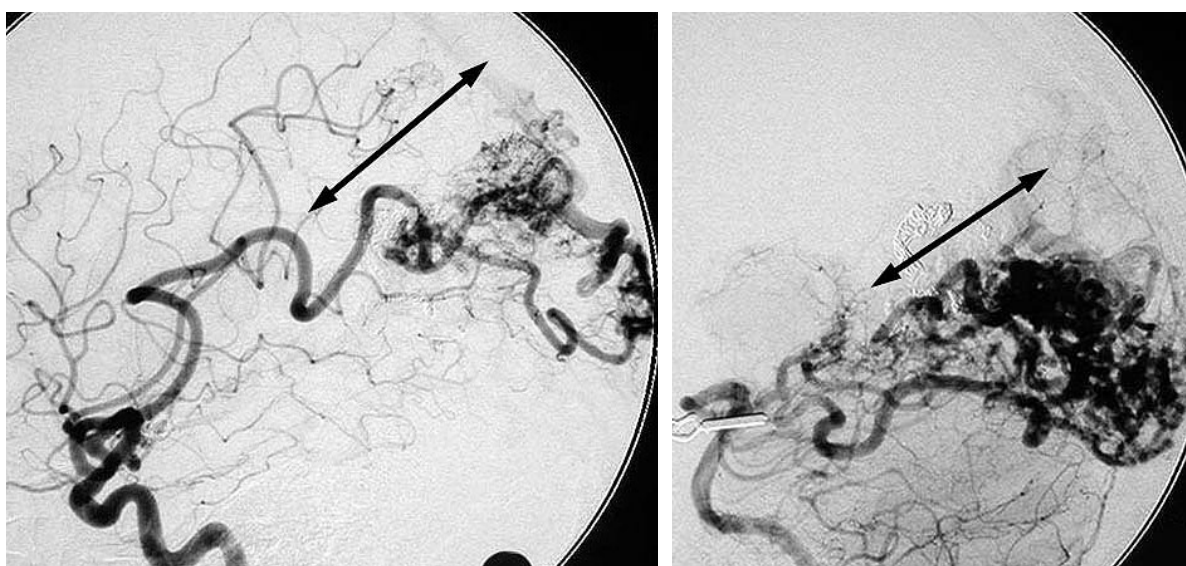


Figure 2 Post-embolization left internal carotid (left) and vertebral (right) artery angiogram of a 24-year-old lady. Arrowed lines indicate the embolized plain at the margin.

Embolization-related complications were seen in seven cases: five were ischemic and two were haemorrhagic. In five ischemic complications, two were transient mild hemiparesis, two were permanent visual field defect and one was disconnection syndrome. The two cases which showed visual field defect were the cases with a large occipital AVM, obliterated even after positive functional test, because the symptom was prospected unavoidable after the surgical resection and the obliteration of the part judged to be beneficial to successful surgical resection. One case resulted in disconnection syndrome was the case with callosal AVM and the symptom was not detected with a functional test. In two haemorrhagic complications, one was a thin perinidal hematoma due to venous occlusion for glue migration at the end of a procedure, and the other was an intracerebellar hematoma due to rupture of a small aneurysm on the feeding artery during a procedure. The former case showed no clinical symptoms; however, the latter showed consciousness disturbance which required emergent surgical resection. Total two cases (3%, 2% in total 91 procedures) showed unexpected permanent neurological deficit.

Illustrative case

This 24-year-old lady suffered sudden onset of headache. A computed tomography scan revealed an intraventricular haemorrhage and an angiogram showed a huge left occipital AVM (figure 1). After six times preoperative embolization with poly-vinyl acetate, the superior-medial and superior-lateral margin of the AVM nidus was obliterated and defended from the functioning left parietal lobe (figure 2). This AVM was successfully removed with a single-staged surgery, and postoperatively, partial visual field deficit remained.

Discussions

Surgical resection of an AVM had a high risk of intraoperative and postoperative bleeding caused by the severe haemodynamic change¹⁴. Since the introduction of stereotactic radiosurgery, the main leading measure for AVM treatment shifted to stereotactic radiosurgery. However, long-term follow-up results of stereotactic radiosurgery for AVM showed its relatively low obliteration rate especially for a high-graded AVM, high bleeding rate before

angiographical obliteration and late reappearance of the previously occluded nidus^{5,9,15,16}.

Stereotactic radiosurgery remains an effective treatment option for treating AVM, especially for deep-seated or brainstem small lesions. However, in a low-graded superficial AVM, the indication of stereotactic radiosurgery should be discussed carefully because of its high incomplete obliteration and bleeding rate and good surgical results.

In a high-graded AVM, surgical resection also has a high risk of perisurgical complications due to the haemodynamic change. In our series of pre-embolization era, the perioperative bleeding rate was high especially in a high-graded AVM, and multi-staged resection was thus applied for avoiding this haemodynamic change¹⁷. For successful resection of a high-graded AVM, the staged preoperative embolization was introduced¹⁸.

In our series of postembolization era showed the improved result of surgical resection in a high-graded AVM with low (2% for each procedure) risk accompanied with preoperative embolization. Staged and repeated preoperative embolization can reduce the flow of AVM stepwisely and reduce the risk of intraoperative severe haemodynamic change for surgical resection of a high-graded AVM. The, preoperative embolization makes haemodynamic and anatomical structures of an AVM simple. Embolization following the functional test makes the margin of the nidus possible to plain from the surrounding brain tissue especially at the eloquent area. Important matter for effective embolization prior to surgical resection is to plan the embolization procedure based on the tactics of the resection surgery and to repeat until obtaining satisfactory obliteration.

Embolization alone has a low potential for complete obliteration of AVM¹⁹ and embolization for AVM should not be planned without conjunction of other treatment.

Conclusions

The goal of treatment of an AVM is complete elimination of the opacification of a nidus. Even huge or high-graded AVMs can be safely removed by a combined-modality approach with preoperative embolization followed by surgical resection. Embolization tactics and material should be selected according to surgical strategies.

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Hisashi Nagashima, M.D.
Interventional Neuroradiology
Center, Aizawa Hospital,
2-5-1 Honjo, Matsumoto
390-8510, Japan